A survey on the public perception of CCS in France

Minh Ha-Duong, Ana Sofia Campos, Alain Nadai

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Abstract

An awareness and opinion survey on Carbon Capture and Storage (CCS) was conducted on a representative sample of French residents aged 15 years and above. About 6% of respondents were able to provide a satisfactory definition of the technology. The key question about 'approval of or opposition to' the use of CCS in France was asked twice, first after presenting the technology, then after explaining its potential adverse consequences. The approval rates, which were 59% and 38%, respectively, show that there is no a priori rejection of the technology. The sample was split in two to test for a semantic effect: half of the questionnaires used "Stockage" (English: storage), the other half "Sequestration." Manipulating the vocabulary had no statistically significant effect on approval rates. Stockage is more meaningful, but does not convey the idea of permanent monitoring.

1 Introduction

France officially supports the European Union's climate policy goal of reducing its CO_2 emissions by a factor of 4 by 2050, as compared to 1990 emission levels. For France, this means reducing emissions by a factor greater than two. A recent scenario-based analysis [Syrota et al., 2007] suggested that without implementing carbon capture and storage (CCS), it will be difficult to reach this target. For example, CCS-free scenarios require improving energy efficiency by a factor of 4 or increasing nuclear production capacity by 71%. In contrast, storing 200 Mt of CO_2 per year might allow a nuclear-free and factor 4 scenario according to de Boissieu [2006], Radanne [2004]. Moreover, the interest in CCS is not purely domestic, as 9 of the 40 largest companies in France (namely

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Air Liquide, Alstom, Arcelor Mittal, EDF, GDF Suez, Lafarge, Total, Suez Environnement, Veolia Environnement) operate in international markets where CCS is arguably a key strategic technology. A clear sign of interest is that in 2008, the French government set up a 400 million euro fund to finance research and development for CCS.

Thus, CCS is being seriously considered in France as an option for a low CO_2 future. Coussy et al. [2009] estimated a scenario in which 60 Mt CO_2 would be stored each year in France in 2050. They found that about half of the capture potential would lie in the energy industry, one-fifth in the steel industry, and the next two industrial sectors with high capture potential would be oil & gas and pulp & paper, at about 10 percent each. The same study also suggested that the Dogger and Trias aquifers in the Parisian basin probably have enough storage capacity for this scenario, although at the estimated rate of sequestration, the Dogger aquifer could be filled up well before 2050.

Much more needs to be understood to know if and how CCS is going to happen, not only technologically but also socially. For example, it is not yet clear whether onshore storage will be used at all. Pipelining sequestered carbon to aquifers under the sea floor of the North Sea and Mediterranean is still an option. In this context, a survey on the possible use of CCS in France was conducted to explore three issues:

- Awareness about CCS in France, and the degree of approval of or opposition to the idea in the general population,
- The variability of this opinion relative to the provision of information,
- The variability of this opinion relative to the semantics used to describe the technology.

Respondents were first asked about their awareness of various CO_2 mitigation technologies. Questions were designed to be comparable with the existing literature on the subject, within the limits of such an inter-cultural exercise. While the sample was aware of several CO_2 mitigation technologies, less than a third of the respondents had heard about CCS, making this technology one of the less well known. Following these questions, the survey was designed as a split-sample, before/after experiment.

In order to examine the effect of information, we asked about approval of or opposition to CCS twice: first after offering a short presentation on the technology, focusing on global warming mitigation; second after explaining its potential adverse consequences. A lower approval could be expected the second time, which was the case, demonstrating that public opinion is not anchored. The main result is that there is no a priori rejection of the technology, but no attraction either.

The semantic effect was analyzed by splitting the sample in two: one-half of the sample was asked about "Storage" (literally in French: stockage), the other half about "Sequestration" (also: sequestration). We found no statistically significant difference in approval rates between the two terms, but respondents found the former term clearer.

The outline of this paper is as follows. Section 2 gives an overview of the questionnaire. Section 3 describes the sample (tabulated in Annex 1, supplementary material available electronically), delivery and analysis methods. Survey

results are reported in section 4 and Annex 2 (supplementary material available electronically), then section 5 discusses implications for the three key issues of awareness, information and semantics.

2 The questionnaire

The questionnaire was developed iteratively starting with a pilot survey described by Ha-Duong and Mardon [2007], itself inspired in part by the work of Palmgren et al. [2004]. After rewriting to consider recent research findings, budget constraints and technical specifications, the questionnaire was further refined through two rounds of pre-testing with workers from the authors' campus. The survey institute helped to simplify and further shorten the final version.

Daamen et al. [2006] explained that one should not expect respondents to know about the subject matter in a survey about CCS. A key methodological issue was then to inform as well as question. Answers should not be interpreted as signs of an already existing opinion but as quick responses to a stimulus, as CCS was a new idea for most respondents. Designing interviews as a two-staged process (before/after information), and structuring the survey as a split-sample (storage /sequestration), allowed us to focus on relative response and analyze the effects of information and semantics.

For each individual, three groups of data were collected. Twelve questions specifically related to CCS were asked, followed by eleven questions addressing the social and demographic characteristics of the respondent. Six additional variables describing the respondent's neighborhood were looked up in a national database. The interview process can be divided in five stages as follows:

1. Questions 1 and 2 were designed to motivate the interviewee and frame the discussion in relation to climate change policy. Then, we inquired about awareness. To this end, question 3 used a list of technologies taken from comparable international surveys, and question 4 used an open direct "According to you, what is ..." approach.

2. There was no question 5. At that stage, the surveyors explained CCS using both a simple textual description of the technology and a graphical description. The text (see Box 1) was shown and read aloud by the surveyor. The diagram (see Figure 1) originally provided by BRGM (France) was simplified by erasing confusing elements such as text legends, chimney fumes, boat transportation and alternative storage types.

3. Questions 6, 7 and 8 asked about personal opinions about the use of CCS in France while varying the word used to describe it [sequestration or storage]. We did not explicitly tell the respondent that we were conducting a split-survey, but this made it clear that we were interested about semantics.

4. We then presented arguments from the social debate around the technology. The text in Box 2 was shown and read aloud. We deliberately did not use the word 'risk', as we believe that this would have elicited an emotional rather than rational response and strongly biased the results. Given the scientific uncertainties and the need for simplicity, we did not

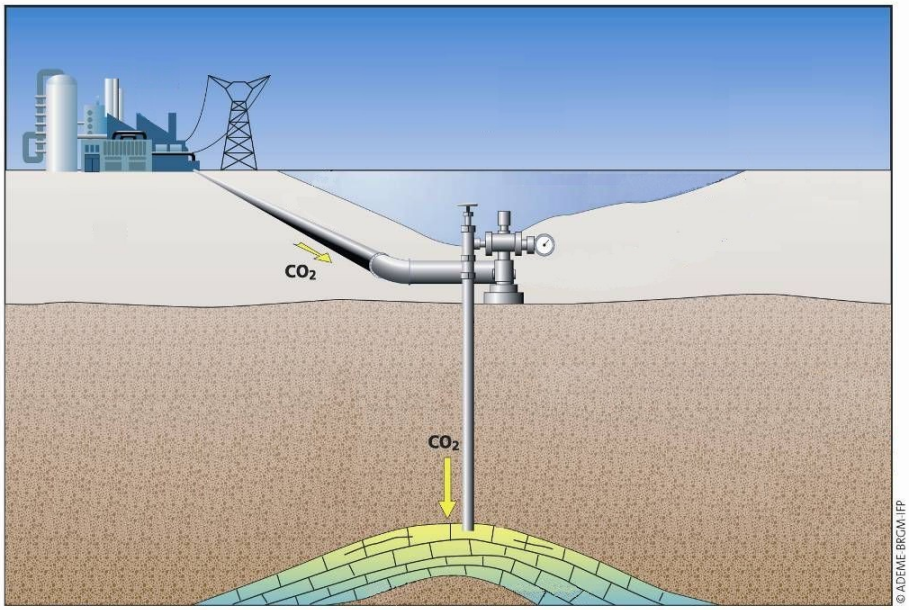

Figure 1: Diagram used to help explain CCS in the SOCECO2 survey. Simplified from BRGM/IFP/ADEME original, with permission.

present any quantification of the effects or their likelihood. Remediation measures were presented. The purpose of questions 9 and 10 was to focus the attention on precaution and on the moral hazard elements of the debate.

5. In the final sequence of the interview, question 11 repeated the key question 6 on the opinion about the use of CCS in France. We then asked a general open question about climate change, and concluded by presenting again the list of energy technologies shown during question 3, asking this time about personal preferences rather than awareness. Personal demographic questions closed the interview.

3 Delivery, sample and analysis

TNS-Sofres, a large reputable survey institute in France, conducted the survey. Respondents were interviewed face to face at home by the TNS-Sofres network of surveyors using a computer-assisted system. The study was done on April 11-12th, 2007, between the two rounds of the French presidential election. Environment was an important issue in the campaign, but CCS was hardly mentioned by the candidates. For example, CCS is absent from Nicolas Hulot's Ecological Pact, which played a central role in the public debates.

The sample of 1076 individuals aged 15 and above was selected by the Institute. It is described in Annex 1. A representative sample of the metropolitan French population (in both subsamples) was achieved using the quota method

Here is a text presenting the principle of CO_2 geological [sequestration — storage]. We will read it together before going on.
CO_2, also called carbonic gas, is found naturally in the earth's atmosphere. Plants require it to grow and to produce the oxygen in the air we breathe.
However, when there is too much CO_2, temperatures rise on the surface of the earth. Today, there is 30% more CO_2 in the atmosphere than 100 years ago, and this is mostly due to energy production (burning coal, oil and natural gas). This increase in CO_2 is the main cause of climate change, which might have important consequences for the environment and human health. To fight against climate change, we must therefore reduce CO_2 emissions. To do so, some political and technical measures should be considered. Among them, one solution has already been experimented in North America, Norway and Algeria. It consists of capturing the CO_2 and injecting it deep underground instead of letting it go into the atmosphere. This method is called geological CO_2 [sequestration — storage]. The principle already exists in nature, since there are many natural underground reservoirs that have kept CO_2 for thousands of years.

Box 1: Translation of the text used to explain CCS in the SOCECO2 survey. [sequestration — storage] is a placeholder for either "storage" or "séquestration".

Here is a second text about the consequences of geological [sequestration — storage]. We will read it together.
The goal of geological [sequestration — storage] is to postpone and limit the effects of climate change. Notwithstanding the difficulties involved in finding appropriate underground locations, scientists question themselves about:

- Leakages by which CO_2 might go back into the atmosphere and cause environmental damage.
- Sudden leakages that might impact human and animal health.
- Increasing the pressure underground could cause gentle ground motion that might damage buildings.
- The possibility that CO_2, a weak acid, contaminates underground rocks and pollutes water.

These effects are not yet well known, and this is the reason why:

- Long term permanent monitoring of [sequestration — storage] sites is planned.
- If problems develop, there are solutions to take back most of the CO_2 injected underground.

Box 2: Translation of the text used to explain the CCS risks in the SOCECO2 survey.

on sex, age, head of household, profession/social category and through stratification on the region and the type of urban area.

In 2005, the total metropolitan French population was about 62.5 million, about 18% of which was less than 15 and 21% above 60. The active population was (ILO definition) 27.6 millions. France's population is aging, urban (42% living in agglomerations of over 100 thousand inhabitants), richer than the world's average (more than half earning over 1.500 euros per month), more educated (42% have a high school degree or higher), and has few children (64% have no children under 15 at home).

Most questions were multiple-choice, with a 'no opinion' option available. Questions 4 and 12 were open-ended. Question 4 asked for a CCS definition. Answers, when given, were encoded as Correct (the respondent redefined "geological storage" using his or her own words), Vague (essentially not wrong, even if remotely related), or Wrong. Question 12 asked "What questions would you like to ask experts". A list of topics of interest was determined from the answers, which were then coded according to that list.

Statistical results presented in sections 4.1, 4.2 and 4.3 below were taken from the summary tables and cross analysis tables provided by the survey institute. In addition to discussing the aggregate results, we comment on subgroups that deviated from the mean answer at a 95% confidence level. We used the following elementary tests, with the R statistical computing environment [R Development Core Team, 2007] for deriving results on the effect of semantics. Answers to questions 3, 4, 6, 11 were given on an ordered but not numerical scale. The Wilcoxon rank sum test with continuity correction was used to compare the answers between the two subsamples of "storage" and "sequestration". Answers to questions 7 and 8 were categorical (yes/no), so we tested if the difference between the two subsamples were significant using the Chi-squared test of the contingency table.

The summary results for the first 12 questions are displayed in Annex 2 (supplementary material available electronically). They are also available electronically from the TNS-SOFRES website. The complete dataset is available on CIRED website [Ha-Duong and Campos, 2007] and as an electronic supplement to this manuscript.

4 Responses

4.1 Awareness of climate mitigation technologies

(Questions 1, 2, 3, 4, 12 and 13)

Let us first examine basic results and how they are affected by the socio-demographic characteristics of the respondents.

The first two questions focused on the interest of the respondent in climate change. On question 1, most respondents (79%) recognized the seriousness of climate change and said that action should be undertaken.

Subsamples significantly more likely to support action against climate change includes respondents 18–34 years old, civil servants, higher-education graduates and those living in the Paris area. The older, retired respondents, those with lower education and those living in villages with less than 2000 inhabitants were less supportive.

Technology	% of respondents having ever heard about it	
	This survey	Other countries
Solar energy	99	∼73
Nuclear energy	97	∼38–85
Wind energy	97	34–87
Biofuels	93	N/A
Energy saving appliances	90	40–68
Hybrid engine vehicles	80	∼85
Hydrogen vehicles	71	26–48
Forest carbon sequestration	48	2–38
Biomass energy	40	10–54
CO_2 storage	34	4–22
CO_2 sequestration	27	4–22
Iron ocean fertilization	16	∼3

Table 1: Awareness of energy technologies relevant for climate change mitigation (SOCECO2 survey question 3). Data for other countries from Reiner et al. [2006], Reiner [2007].

These results are confirmed by the answers to question 12, which was the open-ended question inquiring about what respondents would like to ask if faced with climate change experts. A substantial minority (9%) of answers demonstrated skepticism about the reality of the climate change issues. However, most responses were related to issues of mitigation (22%), impacts (21%), technologies (11%) and actors (6%). This confirms that, broadly, the French public is aware of and interested in the climate change issue.

Question 2 was about the balance between the Environment and the Economy. Again, a large majority of the sample (78%) tilted towards the former. Replies correlated strongly with the previous answer and the population was more or less divided along the same lines. The subsamples of educated, intellectual, left-wing, richer, organic-consuming and Parisian respondents inclined relatively more towards the environment. Subsamples comprising older, retired, less educated respondents, or those living in rural areas or in the center of France, gave relatively more attention to the economy.

Question 3 examined awareness of various energy technologies, mostly following the list used by Reiner et al. [2006]. As Table 1 shows, nearly all respondents declared having already heard about solar energy, nuclear power, wind power, biofuels and energy-efficient appliances. Hybrid engine vehicles and hydrogen vehicles were also well known, albeit to a lesser extent. Less than half of the sample declared being aware of carbon sequestration by forests and of energy from biomass. Geological CO_2 storage or sequestration is clearly a technology most people have never heard about.

Compared to international results (see Table 1), our findings reveal a rather high level of awareness on climate change mitigation options among the French public (or a higher self-confidence bias in France). Note, however, that the wording is critical: the 60% of respondents that had not heard of 'biomass energy' most likely did know what a fireplace is for.

Respondents were asked again to compare technologies at the end of the

survey. Question 13 required them to select, among the same list as in question 3, the three most efficient technological choices to fight climate warming. We used the scientifically simplistic expression "climate warming" because we assumed it was clearer than both "climate change" and "global warming". Despite our posing the question at the end of the questionnaire, CCS remained next to the least efficient technology. It was selected in their top 3 by only 5% of the respondents. Ocean fertilization by iron remained last with 3%.

Results demonstrate that the most heard-about technologies are not necessarily seen as the most efficient: "planting trees and preserving forests to absorb CO_2 in the atmosphere" ranked first on question 13 (57% of respondents selected it) but "carbon sequestration in forests" ranked eighth on the awareness in question 3. Conversely, nuclear energy ranked second on question 3, but seventh on question 13.

Question 4 asked respondents to describe the geologic storage/sequestration of CO_2, using their own words. At that stage, the technology had not been presented by the interviewer. The majority of respondents (72%) declined to answer, which is consistent with the results of question 3 since most reported having never heard about it. Other answers were categorized as exact/vague or wrong. Any reply conveying the idea that CO_2 was being put underground was classified as exact: 6% of respondents offered a correct definition, while 8% demonstrated a vague idea. The 14% of replies that were erroneous often confused CSS with carbon sequestration in forests.

The subsamples of civil servants, better educated, politically involved, richer respondents or those with an intellectual or executive occupation provided significantly better definitions. With respect to gender, more males offered an answer (only 63% of no replies), but more provided an incorrect definition as well (19% versus 14% in the full sample). Less females were to gave an answer (81%), therefore, numerically less got it wrong (10%), but also less got it right (3%).

These results are not directly comparable with previous surveys in other countries, which tried to assess knowledge about CCS by asking which environmental issues CCS helps to solve. However, we believe that such a formulation is very problematic, as it compounds respondents' ignorance about CCS with their ignorance about other environmental issues. For example, RCB Conseil [2005] reports that 15 to 25% of French citizens explain global warming as sun-rays falling through the hole in the ozone layer.

4.2 Reactions to the debate on CCS

(Questions 9 and 10)

Basic information on the principles and the role of CCS in reducing CO_2 emissions were provided as shown in Box 1 and Illustration 1. Box 2 presented information on the potential consequences of CCS.

Question 9 tested how respondents reacted to this shortlist of potentially negative impacts. The no-response rate was rather low (10%). Most respondents (63%) considered that more research was needed.

A small minority (9%) already considered that uncertainties could be controlled enough so as to ensure a good security. This point of view was significantly more frequent among organic product consumers (20%), inhabitants of

the North of France (16%), executives (16%) and higher-educated people (13%). It was significantly less frequent among respondents aged 18–24.

A larger minority (18%) answered that the uncertainties are too large and that this technology should not be used. Nearly a third (29%) of those who believed that concerns about climate change are not justified pointed out that CCS should not be used. In short, skepticism on the climate change issue tends to imply opposition to CCS. This intuitive result was already apparent in the pilot survey and in the previous literature, see for example Itaoka et al. (2004). However, there are subsamples in which this a priori rejection of the technology is less frequent. They include executives (7%), parliamentary right sympathizers (13%), families of 5 or more (11%), incomes above 3.000 euros (10%) and Parisians (10%).

Question 10 was a choice between two propositions. Proposition one framed CCS positively, stating that it allows us to benefit from the existing coal and oil reserves. Proposition two depicted CCS as a moral hazard, stating that it potentially discourages the development of renewable energy technologies. The response rate was lower than at question 9, with 21% of no-opinion. This is not surprising, since the question was more complicated. But as a way to focus the respondent's attention on the main CCS pros and cons, we felt that asking this question was probably more efficient than an academic standalone explanation.

Only an 18% minority leaned towards the idea that CCS is a good transition technology. This rate was significantly higher among teen-agers (32%), respondents living in the North of France (30%), consumers of organic goods (29%), and those living in an area with low unemployment. It was lower (9%) among young adults aged 18–24.

Most respondents (61%) rather inclined towards the idea that CCS could be an excuse to avoid changing the way we produce energy. Dispersion between subsamples is larger than for other questions. The use of CCS tended to be seen as an ecological alibi particularly by members of consumer organizations (84%), ecologists (77%), adults 18 to 49 years old (77% of the 18–24 age class, 69% of the 25–34 and 70% of the 35–49), respondents with high levels of income (75%) and highly graduated (72%), executives, middle-managers and employees (72%).

This confirms the salience of the moral hazard. In a survey context, Itaoka et al. [2004] has shown that it is a significant factor influencing public opinion on CCS. This aspect is also important in NGOs' discourse, for example Moussally [2007], speaking for the Climate Action Network France, argued that financial public support should be used to promote energy efficiency rather than CCS.

4.3 Approval of or opposition to CCS

(Questions 6 and 11)

The survey asked about approval of or opposition to the use of CCS in France twice: before and after providing information on CCS risks. It used a 4-point scale in order to purposely force an informative answer.

The first time we asked, in question 6, a majority of respondents (59%) were positive, 48% being rather supportive and 11% strongly supportive. The rate of approval was significantly higher among respondents aged 15–17 (73%), respondents living in the North of France (69%), those identifying politically

with the right (66%) and those working in the trade sector (71%). Rate of approval was significantly lower in the subsample of respondents with elementary education only (51%) and those living alone (48%).

Less than a quarter (21%) were opposed to the use of CCS in France: 14% rather opposed, 7% strongly opposed. Opposition was significantly higher than average among respondents with middle-scale professions (32%) and lower than average among those identifying politically with the right (15%).

The non-response rate was 20%. It was significantly higher among respondents aged 62 and older (32%), with elementary education only (30%), living alone (28%), retired (27%), in Paris area (27%) or in communities with a large amount of social housing (25%). It was significantly lower for respondents in the trade sector (7%), those living in the North of France (10%), in a family of four (12%), and for high-school-only graduates (12%).

Question 11 repeated the text of question 6 on approval of or opposition to the use of CCS in France. Compared to the initial reactions when the principle of the CCS was presented, lower approval rates could be expected and were found.

On the whole, the approval rate was 38%, down from 59% in question 6. As previously, it was significantly higher (50%) among respondents aged 15–17, and those identifying politically with the right (47%). It was also significantly higher among executives and intellectuals (48%), and non-working persons in the highest income bracket considered (50%). The rate of approval was significantly lower in the 35–49 years age range (31%), for ecologists (26%) and respondent without a political preference (31%).

The opposition rate was at 42%, compared to 21% in question 6. Opposition was stronger among ecologists (60%), lower income respondents (55%), workers (54%), employees (52%), and respondents between the ages of 35 and 49 (53%). Opposition rates were lower in Paris (33%) and in urban areas with low unemployment (33%), as well as for respondents identifying politically with the right (34%) and non-working persons in the highest income bracket (24%).

The rate of no-reply was comparable for questions 6 and 11, about 20%.

Illustration 2 displays the 1076 individual responses (contingency table) to questions 6 and 11. Most points lie on the diagonal. They represent people who did not change opinion (or absence of). Points above the diagonal represent people who decreased approval (or moved to 'no opinion' if they lie on the first row). A large fraction (29%) of the sample initially favorable to the use of CCS in France switched views and showed opposition ex post. There was much less change in the other direction, towards a more favorable view.

The large variation between the answers to questions 6 and 11 shows that opinions are not firmly anchored. Approval rates decline when the respondent's attention is focused on the uncertain local consequences rather than on the global climate benefits.

5 Discussion

This section discusses the main SOCECO2 survey findings, comparing them with previously published results when possible. It successively deals with socio-demographic correlates of approval rates, the effect of information provision and

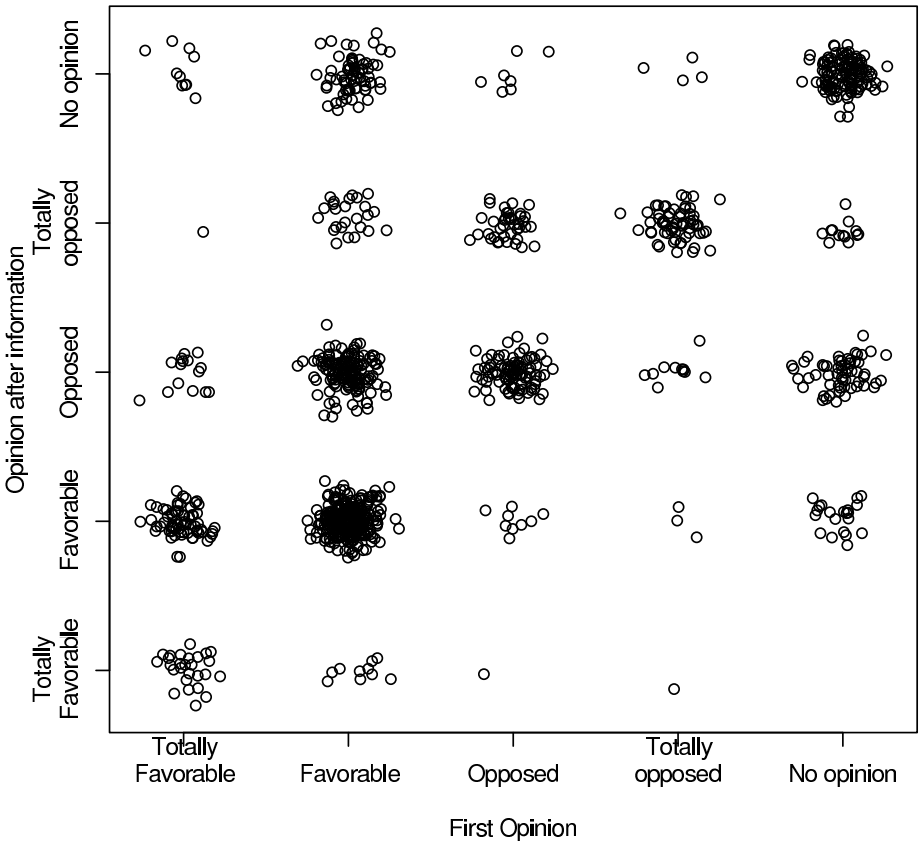

Figure 2: Initial and revised degree of approval on CCS.

the effects of semantics.

5.1 Socio-demographic correlates of awareness and approval

It is well established in the survey literature that age, gender, occupation and education are important correlates of item non-response [Ferber, 1966, Francis and Busch, 1975]. More precisely, lower response rates and more 'no opinion' replies are more frequent in respondent groups of lower social status. This pattern was also apparent, for example, in the wind energy acceptability survey conducted by Faulkenberry and Mason [1978].

Miller et al. [2007] found that compared to men, women were less accepting of CCS and more concerned about safety, risk and effectiveness, in a survey conducted on the Australian public. But given the previous effect, being less accepting does not necessary mean that women are more opposed. It could be that they more frequently abstain from giving an opinion.

Indeed results displayed in Table 2 show that aged or retired respondents as well as those less educated or living in underpriviledged neighborhoods tended more often to abstain from giving an opinion in the SOCECO2 survey. Accordingly, they are less often supportive of the technology, but also less often opposed to it. As in many countries, age and education level measured by highest diploma obtained are highly correlated in France, as the average duration of schooling has increased greatly during the last 50 years in France.

We also found that gender and the opinion on CCS were significantly correlated (Chi-squared test, $p = 0.011$ for question 6, $p = 0.037$ for question 11). Table 2 shows that women tend to be less accepting than men, but not much more opposed, because they more frequently offer "no opinion". As discussed above, this is not CCS-specific.

Miller et al. [2007] reported that respondents with a higher education were more aware of the greenhouse gas debate and supportive of CCS, whilst younger Australians were more trusting that information providers 'told the truth' about CCS, and women were more concerned by uncertainties. SOCECO2 results also found that respondents holding executive positions or intellectual jobs were more frequently supportive of the technology than those in other job categories. This is also true for respondents in the highest income bracket. This holds for both ex-ante and ex-post opinions (questions 6 and 11), even if the deviation is not always significant at a 95% confidence level.

The SOCECO2 survey also replicates Miller et al.'s finding that the public lacked knowledge about CCS but was willing to engage and learn about this technology. More precisely, on Question 12 a large majority (76%) of respondents had questions that they would like to ask experts in climate change, if they had the opportunity to do so.

Finally, we consistently found that respondents in the North of France tended to deviate significantly from the average (better awareness, more favorable to CCS, more inclined to perceive it as a good transition). One interesting assumption that could be made, but was not explored in this survey, would be to relate this deviation to the past importance of mining activity in this region.

In summary, the socio-demographic variability of CCS approval rates can mostly be explained by effects relatively well known in survey research. Respondent behavior is governed both by the motivation to reply and by the

	Q6. Initially on CCS (%)			Q11. Finally on CCS (%)		
	Favor	Oppose	No opinion	Favor	Oppose	No opinion
Whole sample	59	21	20^{-}	38	42	20
Men	62	22	16^{-}	41	42	17
Women	56	21	23	34	43	23
Age 15–17	73^{++}	15	12	50^{+}	38	12
Age $\geq$65	52	16^{-}	32^{++}	33	33^{-}	34^{++}
Elementary education	51^{--}	19	30^{++}	32^{-}	39	29^{++}
College education	62	22	16	43	42	15^{-}
Lowest social housing	63	51	16^{-}	42	44	14^{--}
Highest social housing	53	11	25^{++}	38	38	24^{+}
Politically green	53	29	18	26^{--}	60^{++}	14
Politically right	66^{++}	15^{--}	19	47^{++}	34^{--}	19
No political preference	54	21	25^{+}	31^{--}	42	27^{++}

Note: $^{-}$, $^{--}$, $^{+}$, $^{++}$denote values statistically significantly below or above average at the 90% and 95% confidence levels.

Table 2: Socio-demographic effects in SOCECO2 survey. We asked respondents their opinion about CCS on question 6 after a short presentation of the technology and once again in question 11 after a short presentation of the uncertainties. Column "Favor" shows the sum of responses "Completely favorable" and "Rather favorable". Column "Oppose" shows the sum of responses "Completely opposed" and "Rather opposed."

cognitive capacity to form an opinion. We conjecture that because of the characteristics of CCS, these factors play in opposite directions here. Motivation for a survey about protecting the climate may be higher than motivation for a typical consumer or political survey, but no-reply socio-demographic effects remain because the cognitive skills involved are also much higher.

5.2 The effect of information provision

The scientific literature about the effect of information provision on CCS approval is ambiguous. Palmgren et al. [2004] found that interviewees' initial dislike for geological and oceanic carbon sequestration relative to other carbon management options seemed to increase with the provision of more detailed information. On the contrary, Itaoka et al. [2004] found that the more information respondents obtained about CCS, the more likely they were to support those storage options, with the exception of onshore geological storage. Similarly, Shackley et al. [2005] reported that in the absence of information, the majority of people either do not have any opinion about carbon storage or are somewhat skeptical about it, but once information is provided as to its role in reducing CO_2 emissions, opinion shifts considerably towards a slight support for the concept.

The two surveys reported by Curry et al. [2007, VIII] also showed a significant impact of information. Respondents in the United States were asked to choose one energy technology to address global warming. Half of the sample received no information and the other half received information about the various technologies, such as: their costs, their efficiency in reducing emissions CO_2

and their current share in electricity production. Informed respondents chose CCS more frequently than uninformed respondents, at the expense of renewable energies. But these findings can hardly be compared with those from our study, because qualitatively different information was presented. In the study of Curry et al, the information provided was strictly focused on relative costs aspects. It included much less information on the principle of CCS and its risks than the SOCECO2 survey. Thus, respondents who selected CCS among other technological choices did so based on a differently incomplete information package.

Considering that the difference between questions 6 and 11 arises only because respondents have been informed about the technology might suggest that acceptability decreases when information increases. Yet, this would implicitly reduce information to a quantitative asset, neglecting that its content (quality) as well as the type of situation in which it is provided are decisive. The qualitative difference in information between questions 6 and 11 is that we initially explained the necessity of CCS, then the risks associated with it.

Our results do not mean that withholding information might increase the acceptability of CCS projects. On the contrary, they can be read as suggesting that initially high approval rates can decline if initial opinions are based on an incomplete information set.

Our survey approached CCS as a generic technology. As in the case of other technologies, such as wind power, the acceptance of local projects might be very different than that of generic technology [Bell et al., 2005, Nadaï and Labussière, 2009]. At the local level, Not In My Backyard (NIMBY) effects, environmental justice, planning procedures, the historical context and other specific features can drive opposition to or approval of a local project . In the case studied by de Figueiredo et al. [2002], the storage experiment was planned off- shore, into the deep ocean, but sovereignty of native populations became an issue. That case clearly showed that being late to reach out to the public can be fatal to a planned storage experiment.

As Bourdieu [1973] explained, questionnaire-based surveys create very artificial communication situations. In reality, people form opinions through dialogue. Actual opinions are diverse, volatile and historically and situation-dependent. "Public opinion" is a statistical construct, as is the half male, half female "average individual.". A known bias is that when answering a questionnaire, people tend to pay more attention to what they have heard last. Accordingly, answers to question 11 are influenced by risk considerations and oriented towards a negative view of CCS. For these reasons, the average answer to question 11, that is a rate of approval at 38%, is not a better approximation of a pre-existing 'public opinion' than the average answer to question 6, at a rate of 59%. These two values might only be interpreted as a range, which can be compared to other ranges obtained in other surveys that ask similar 'approval of/opposition to' questions.

5.3 Semantics: Storage vs. Sequestration

We examined how answers changed according to the use of "storage" (storage) or "sequestration." (see also Annex 2 result tables) First, does the degree of approval change with the word used to describe the technology?

The pilot survey found that the word "sequestration" tended to arouse higher

rates of approval. In this survey, when basic information was provided the approval rate for "sequestration" was 60%, against 58% only for 'storage' (question 6). The difference was even larger at the end of the questionnaire: 40% versus 35% for the "storage" half of the sample (question 11). The balance tilted in the same direction.

But the difference between the two halves of the sample was not statistically significant. On question 6 (ex ante opinion), approval rates differed by only 2%. The hypothesis that 'the semantics has no effect' easily passes the two-sided Wilcoxon rank sum test ($p = 0.2004$[1]). On question 11 (ex post opinion), we tested the one-sided hypothesis that approval rates in the half-sample with "sequestration" was larger than in the half-sample with "storage". Here again, $p = 0.1376$ is large, so the hypothesis does not hold. We conclude that statistically, semantics do not significantly influence the respondent's degree of approval.

Considering the effect of semantics elsewhere in the questionnaire, "storage" appears clearer than "sequestration." Answers to question 3 (awareness) show that people were more aware of "storage" than "sequestration." The difference is statistically significant (Wilcoxon rank sum test with continuity correction, one sided, $p = 0.0386$). Moreover, question 4 (open ended, CCS definition) shows that people were able to provide a better description of the technology when it was called "carbon storage" than "carbon sequestration" (Wilcoxon rank sum test with continuity correction, one sided, $p = 0.0796$). Since that question had a high no-response rate, 72%, we conducted the same test in the subsample that provided a definition. The difference here is even more statistically significant ($p = 0.0006$). This is congruent with the result from question 7, where more people faced with "storage" considered that the name of the technology helped to understand what CCS is about (62% versus 48% in the "sequestration" subsample). The difference is significant (Chi-squared test for independence between the semantic and the reply to question 7, $p < 10^{-5}$).

On Question 8, more people faced with "storage" considered that the name of the technology gave a good image of it (44% versus 33% in the "sequestration" subsample). Here again the difference is significant (Chi-squared $p = 0.000197$). This contradicts the survey results, since we found that *sequestration* had higher rates of approval. It seems that the public is not a reliable assessor of its own opinion. However, the difference between questions 6 and 11 approval rates may be a fluke, since it was not statistically significant at the usual confidence levels. Alternatively, although we intended 'a good image' to mean *favorable*, it may be that most respondents interpreted it as *clear*.

[1]Reminder on statistical testing: $p = 0.2004$ means that, assuming the two subsamples come from the same distribution, there is a 20 percent probability that the difference will be as large as observed or larger, just by chance. Thus, it cannot be ruled out with confidence that the distributions differ. Although it is possible to conduct many different tests to measure the statistical distance between the two samples, there is no reason to report them all. This is because, as always in statistical testing, if the hypothesis is clearly supported by the data, then all and any good test will be conclusive, but if the hypothesis is not supported, then no amount of additional testing will make the data clearer.

6 Concluding remarks

Carbon capture and storage can only be accepted if one recognizes that climate change is a serious issue and that reducing CO_2 emissions is a necessary answer. Our survey shows that climate change is largely recognized by the French public as a serious problem calling for action. Overall, the sample said that the environment/economy balance tilts toward the former term. Yet, several alternative sources of energy remain unknown and the request for information is real, in particular about the causes of climate change and its possible solutions.

This depicts a general background in which the idea of carbon capture and storage could potentially fit positively. However, this technology is not known by the large majority of the French public. Only about a third of the population declared having heard about it and only one in twenty respondents were able describe its principle correctly.

It is important to understand how the public learns or might learn about CCS. The rate of approval was insignificantly higher when the word "sequestration" was used to describe the technology, compared to the same description using the word "storage," but the word "storage" appeared clearer than the word "sequestration," even if the former does not convey the idea of monitoring and irreversibility. There seems to be a general agreement in France to use the "storage" word.

Overall, this study reveals that French public is not strictly opposed to carbon capture and storage, but rather more suspicious than supportive. Support is conditional at best, and its level depends critically on technical risks and the political use of this technology.

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Annex 1: Sample description

Sex

M	F
506	570

Age

15–17	18–24	25–34	35–49	50–64	65+
60	106	153	286	253	218

Occupation of the house head

Business, Craftsman	Manager, Intellectual	Intermediate	Employee	Blue Collar	Inactive, Retired	NA
43	116	154	133	238	380	12

Respondent's occupation

Business, Craftsman	Manager, Intellectual	Intermediate	Employee	Blue Collar	Inactive, Retired	NA
31	76	112	193	140	516	8

Education level

Elementary	Middle school	High school	College+	NA
237	368	163	290	18

Household size

1	2	3	4	5+	NA
193	379	165	201	136	2

Number of children under 15 at home

0	1	2	3	4	5	6	7
693	162	151	54	9	3	3	1

Political affiliation

Left	Green	Parliamentary right	Extreme right	None
388	73	310	49	256

Employment status

Self employed	Public sector	Private sector	Unemployed	Retired	Other	NA
61	149	278	77	312	197	2

Income category (euros per month)

Active	≤1.200	1.201–1.500	1.501–2.300	2.301–3.000	over 3000
	90	77	128	141	145
Inactive	≤800	801–1200	1201–1500	1501–2300	over 2300
	54	53	44	60	80
NA					
204					

Sector of activity

Industry	Building	Trade	Transport	Services	NA
137	42	110	50	365	372

Agglomeration size

< 2k	2–20k	20–100k	>100k	Paris area
289	197	133	318	139

Neighborhood type

Urban center	Suburban	Country	Isolated rural	NA
553	192	155	116	60

City unemployment rate

very small	small	large	very large
197	193	274	412

Density of social housing in city

Very small	small	large	very large
429	153	101	393

Density of worker's households in city

very small	small	large	very large
179	141	261	495

Region of France

Nord	Ouest	Sud-ouest	Sud-est	Centre	Est	Paris
116	191	141	218	129	118	163

Annex 2: Questionnaire results

Question 1: Which of the following opinion is the closest to yours?

There is no doubt as to the seriousness of climate change, and an immediate answer is required	45
There is enough evidence behind the reality of climate change, and action should be taken	34
We do not have enough knowledge about climate change, more research is required before deciding anything	14
Worries about climate change are not grounded	4
No opinion	3
	100%

Question 2: As a general matter, how do you rank the protection of the environment as compared to economic development?

The protection of the environment should have the priority even if it is at the expense of economic development	28
Economy is as important as the environment, but we should give priority to the protection of the environment	50
Economic development is as important as the environment, but we should give priority to economic development	15
Economic development should have priority even if it is to the expense of the protection of the environment	2
No opinion	5
	100%

Question 3: For each of the following technologies, could you tell me if you have heard about it?

	Yes and you know what it is about	Yes but you don't know what it is about	No	No opinion
Solar energy	91	8	1	0
Nuclear energy	84	13	3	0
Wind energy	89	8	3	0
Biofuels	77	16	7	0
Energy saving household appliances	76	14	10	0
Hybrid combustion vehicles	62	18	19	1
Hydrogen vehicles	47	24	28	1
Carbon sequestration in forests	27	21	51	1
Nanotechnologies	23	20	56	1
Biomass energy	19	21	59	1
CO_2 geological storage	12	22	65	1
CO_2 geological sequestration	11	16	72	1
Sea fertilization with iron	5	11	83	1

Question 4: According to you, what is CO_2 geological [sequestration / storage]?

Base:	Full sample	Sequestration	Storage
Exact answer	6	4	8
Vague answer	8	9	7
Wrong answer	14	17	11
No opinion	72	70	74
	100%	100%	100%

There was no Question 5. Figure 1 and box 1 were shown at this point.

Question 6: Yourself, would you be a priori completely favorable, rather favorable, rather opposed or completely opposed to the use of CO_2 geological [sequestration / storage] in France?

Base:	Full sample	Sequestration	Storage
Completely favorable	11	13	10
Rather favorable	48	47	48
Rather opposed	14	12	16
Completely opposed	7	7	7
No opinion	20	21	19
	100%	100%	100%

Question 7: And would you say that the word [to sequester / to store]:

	Sequester	Store
Helps rather well to understand what it is about	48	62
Does not really help to understand what it is about	46	31
No opinion	6	7
	100%	100%

Question 8: And would you say that the word [to sequester / to store]:

	Sequester	Store
Gives a rather positive image of what it is	33	44
Gives a rather negative image of what it is	54	42
No opinion	13	14
	100%	100%

Box 2 was shown at this point.

Question 9: Regarding the possible effects of [sequestration / storage], which of the following sentences is the closest to your opinion?

Base:	Full sample	Sequestration	Storage
Uncertainties can be mastered to make it safe	9	10	8
Uncertainties are worrisome, we need more research before going ahead	63	65	61
Uncertainties are too big, we should not use this technology	18	15	20
No opinion	10	10	11
	100%	100%	100%

Question 10: Personally, which of the following opinions is the closest to what you think?

Base:	Full sample	Sequestration	Storage
Geological sequestration/storage will allow us to continue consuming our coal and oil reserves.	18	19	18
Geological sequestration/storage might be an excuse for keeping our ways of producing energy unchanged	61	61	61
No opinion	21	20	21
	100%	100%	100%

Question 11: Finally, are you completely favorable, rather favorable, rather opposed or completely opposed to the use of CO_2 geological [sequestration / storage] in France?

Base:	Full sample	Sequestration	Storage
Completely favorable	4	4	3
Rather favorable	34	36	32
Rather opposed	29	27	32
Completely opposed	13	13	13
No opinion	20	20	20
	100%	100%	100%

Question 12: And if you were faced with experts in climate change, which are all the questions you would like to ask them?

What are the causes of climate change	3
What are the solutions to climate change	14
What can we do at an individual level / which simple things	3
How can we make people aware of it	1
why didn't we do something before	1
Total "Fight against climate change"	*22*
What are the alternatives / alternative technologies	4
What is the efficiency of biofuels	0
What is the ecological impact of nuclear energy	0
Clarification about the risks associated with CO_2 geological sequestration / storage	7
Total "Alternative / alternative technologies"	*11*
What are the dangers/consequences/risks	11
Aren't we already at a point of no return/ is it not too late, already unavoidable	4
Deadline/ when will the consequences of climate become perceptible	6
How long before the point of no return	0
Total "Impact of climate change"	*21*
Is climate change as dramatic as experts say	3
Is it true/ are the surveys reliable	4
Isn't climate change a natural phenomenon	2
Total "Veracity of climate change"	*9*
Will countries collaborate / how to get them cooperate / why they all sign the Kyoto protocol	4
What can we do against polluting industries	2
Total "Actors of climate change"	*6*
Others	5
Not relevant	5
No opinion	26

Total is greater than 100, respondents could give several answers.

Question 13: According to you, what would be the three most efficient actions to fight climate change?

Plant trees and save forests to absorb CO_2 from the atmosphere	57
Generate solar electricity	53
Produce cars that consume less energy for the distance	48
Produce appliances that consume less energy for the same service	41
Produce electricity from wind, with wind turbines	37
Produce electricity from wood, agricultural waste, or energy crops	23
Produce nuclear energy	10
Get the CO_2 back to sequester/store it underground	5
Add iron to the sea so as to increase CO_2 absorption by plankton	3
No opinion	3

Total is greater than 100, respondents could give up to three answers.